



Original Article

The duration of stage transition during pharyngeal swallowing among young-elderly, and mid-elderly individuals

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Abstract. [Purpose] Understanding the normal movements of the pharyngeal stage is important in the assessment of dysphagia. This study classified an elderly population into young-elderly and mid-elderly individuals and investigated the difference in stage transition duration between the two groups to provide basic material for assessment of dysphagia in old age. [Subjects and Methods] The subjects of the study were 12 middle-aged individuals (40–49 years), young-elderly individuals (65–74 years), and 9 mid-elderly individuals (75–84 years). Stage transition duration was defined as the time from the moment food boluses passed the ramus of the mandible until the start of upward movement of the hyoid. All image data were measured using a videofluoroscopic study. Difference in measured values for stage transition duration between the groups were confirmed with one-way analysis of variance. [Results] Although analysis of variance was significantly longer in the young-elderly and mid-elderly individuals than in the middle-aged individuals, there was no significant difference in stage transition duration between the young-elderly and mid-elderly individuals. [Conclusion] In this study, there was no significant difference between the young-elderly and mid-elderly individuals in the movement speed of muscles related to pharyngeal swallowing.

Key words: Pharyngeal swallowing, Stage transition duration, Dysphagia

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INTRODUCTION

Swallowing is a complex coordination of movements of muscles that enable food to move through the pharynx and esophagus into digestive organs such as the stomach¹⁾. There are four stages of swallowing: the oral preparation stage, in which food boluses are formed by chewing; the oral stage, in which food boluses are moved by the tongue; the pharyngeal stage, in which food boluses are inserted into the pharynx; and the esophageal stage, in which food is moved to the stomach through the esophagus. Dysphagia is defined as problems arising in this process¹⁾.

The pharyngeal stage is an involuntary stage in which pharyngeal swallowing occurs as food boluses pass through the anterior faucial arch. In this stage, the soft palate and larynx are raised so that food boluses do not enter the air passage, which is closed by pharyngeal constriction²⁾. If problems arise in this process, aspiration or penetration, which is passage of food boluses through the air passage, can take place³⁾, and, in severe cases, patients can die of aspiration pneumonia⁴⁾. Thus, understanding the normal movements of the pharyngeal stage is important in the assessment of dysphagia.

As a result of numerous studies on muscle coordination in the pharyngeal stage, it was found that various and complex movements occur in the stage, such as hyoid excursion, epiglottic downward movement, pharyngeal constriction, laryngeal closure, and upper esophageal sphincter opening^{2,4)}. That is, for a normal pharyngeal swallowing to take place, the following processes are required: first, the velum opens so that food boluses do not enter the nasal cavity; second, the hyoid and larynx are raised; third, the air passage is closed by vocal folds and the epiglottis so that food boluses do not enter it; fourth the cricopharyngeal sphincter opens so that food enters the esophagus through the pharynx; and fifth, the pharyngeal constrictor

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muscle contracts. This muscle coordination in pharyngeal stage takes place within 1 second and if pharyngeal swallowing is postponed, there is a high possibility of aspiration after swallowing¹.

In clinical settings, the stage transition duration (STD), which focuses on the change in location of the hyoid, is generally used as a measuring method to verify postponement of pharyngeal swallowing⁵. The STD measures the time from the moment food boluses pass the ramus of the mandible until upward movement of the hyoid starts and is known as a measurement variable with high sensitivity⁶.

In order to measure the STD, precise understanding of pharyngeal swallowing in the normal aging process is required. Many studies have confirmed that the STD is gradually delayed with the progress of aging⁷ and that elderly individuals have a significantly longer pharyngeal delay than young adults⁶⁻⁹. Most of these preceding studies, however, were limited to comparison of STD between young adults and the elderly, and little is known about the physiological change in pharyngeal swallowing with the progress of aging in old age.

In sum, as the range and speed of muscle movements related to pharyngeal swallowing change with age, investigation on the change in STD in the aging process is important in distinguish normal aging and dysphagia. There is a particular lack of studies on the STD in elderly individuals even though the mid-elderly population over the age of 75 is rapidly increasing worldwide.

This study classified an elderly population into the young-elderly and mid-elderly individuals and investigated the difference in STD between the two groups to provide basic material for assessment of dysphagia in old age.

SUBJECTS AND METHODS

The subjects of the study were 12 middle-aged individuals (5 males, 7 females, average age of 45.5 ± 2.1 years), 10 young-elderly individuals (3 males, 7 females, average age of 68.7 ± 1.9 years), and 9 mid-elderly individuals (1 males, 8 females, average age of 79.1 ± 1.9 years). They were given a sufficient explanation regarding the purpose and experimental method of this study before participating and gave voluntary consent. The protocol was approved by the Institutional Review Board of BMH hospital and was conducted in accordance with the ethical standards of the Declaration of Helsinki. As pharyngeal swallowing is not affected by gender¹⁰, this study did not consider the gender ratio of the subjects. No subject had a history of dysphagia and was diagnosed with neurological diseases such as stroke.

This study used Multistar T.O.P. radiography (Siemens) to perform a videofluoroscopic study (VFSS), a C40D digital movie camera (Sanyo) for video recording, and VirtualDub ver 1.10.4, which is capable of analyzing images at 30 frames per second, for analysis of video data.

Video materials were collected in the Department of Radiology of A Hospital in Incheon City, South Korea, from June 5 through August 13, 2014, with the help of residents of rehabilitation medicine. The test process for VFSS was as follows; first, the tester gave the subjects 5 cc of a thick liquid that contained 22% barium sulfate; second, the subjects swallowed the thick liquid according to the directions of the tester; and third, the tester filmed the lateral view of the swallowing process.

The STD was defined as the time from the moment food boluses passed the ramus of the mandible until the start of upward movement of the hyoid⁵ (Fig. 1). As the result of re-measurement of video material, reliability among testers was 95%.

Differences in the measured STD values between the groups were confirmed with one-way analysis of variance (ANOVA). Tukey's test was applied for post hoc comparisons. IBM SPSS Statistics 22.0 (IBM Corp., Armonk, NY, USA) was used for all analyses, and the significance level was 0.05 in two-sided testing.

RESULTS

The STD values of the middle-aged, young-elderly, and mid-elderly subjects are presented in Table 1. One-way ANOVA revealed significant differences in STD among groups ($p < 0.05$). Tukey's test revealed that although the average STD was significantly longer in the young-elderly (0.48 ± 0.05) and mid-elderly subjects (0.50 ± 0.04) than in the middle-aged subjects (0.35 ± 0.02), there was no significant difference in STD between the young-elderly and mid-elderly subjects.

DISCUSSION

In order to assess dysphagia, knowledge about the normal process of swallowing is required, and it is especially important to know the changes in speed of swallowing with aging.

Analysis of the average STD values of the middle-aged, young-elderly, and mid-elderly subjects revealed that although the average STD was significantly longer in the young-elderly and mid-elderly subjects than in the middle-aged subjects, there was no significant difference in STD values between the young-elderly and mid-elderly subjects, which corresponds to the results of previous studies that compared times of oropharyngeal swallowing with age^{7, 8}.

Concerning the reason for the significant difference in pharyngeal swallowing function between the young adults and the elderly, Logemann et al.¹¹ explained that the range of upward movement of the larynx and hyoid decreases due to a decrease in the reserve of neural muscles with age. In a study that compared oropharyngeal swallowing between young adults aged 21 to 29 and the grand elderly aged 80 to 94, the authors reported that although there was no significant difference in anterior

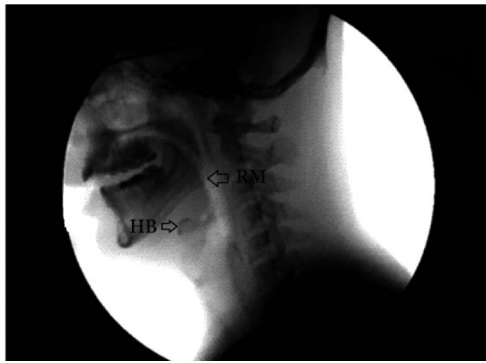


Fig. 1. Reference points for stage transition duration
HB: hyoid bone; RM: ramus of the mandible

Table 1. STDs of the middle-aged, young-elderly, and mid-elderly subjects
Unit (sec)

	mean	SD
Middle-aged	0.35	0.02
Young-elderly	0.48 ^a	0.05
Mid-elderly	0.50 ^a	0.04

^aGreater than the middle-aged subjects

^bGreater than the young-elderly subjects

movement of the hyoid and larynx until opening of the cricopharyngeal muscle, only the larynx of the young adults continued to rise after the opening of the cricopharyngeal muscle¹¹).

Since aspiration can take place before swallowing when food boluses pass the air passage before the completion of air passage closing, which is achieved by the hyoid and larynx rising, due to a delay in the pharyngeal swallowing time, the elderly are exposed to a higher risk of swallowing problems than young adults³). Nevertheless, there was no significant difference in STD between the young-elderly and mid-elderly subjects in this study, which implies that there might be no significant difference in the decrease in the reserve of neural muscles after old age. As pharyngeal swallowing is coordination function of various muscles, analysis of the movement range of the hyoid and larynx of the young-elderly and mid-elderly individuals is required in the future.

Limitations of this study are as follows: first, as the number of subjects was small, it is difficult to generalize the study results. Second, this study did not investigate the difference in STD based on the viscosity of the food boluses, and this should be studied in the future.

In this study, there was no significant difference between young-elderly and mid-elderly subjects in the movement speed of muscles related to pharyngeal swallowing. Systematic investigation of the changes in swallowing in the aging process will make a more reliable assessment possible on old-age swallowing disorder.

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